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学位授与の題目	Petrology of Paleozoic high-pressure metamorphic rocks in southwestern Japan: petrologic and geochronologic constraints for Paleozoic subduction tectonics（西南日本の古生代高圧変成岩：古生代沈み込みテクトニクスの岩石学的・地球年代学的解明）
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学位論文要旨

Abstract

The regional studies of the Early to Late Paleozoic subduction-related high-pressure metamorphic rocks in the Inner Zone of southwestern Japan revealed that the two different subduction events in Late Paleozoic and Early Paleozoic had taken place in the paleo-Pacific margins. Late Paleozoic subduction is characterized by high-pressure and low-temperature (HP/LT) schist of the Renge metamorphic belt, which generally occur as tectonic blocks in serpentinite melange beneath the Oeyama ophiolite nappe. Although the Renge metamorphic belt has been fragmented during exhumation and nappe emplacement, systematic K-Ar age determination of phengite from blueschist tectonic blocks within a serpentinite melange suggest a primary coherency of the blueschist-facies metamorphic sequence. In Chugoku Mountains, typical high-pressure type schists of lawsonite-blueschist to epidote-blueschist facies occur, and a block of garnet-glaucophane schist, which preserves relics of the peak eclogite facies assemblage (garnet + omphacite + glaucophane + rutile + quartz) and earlier-stage amphibolite-facies assemblage, occur together with lawsonite-glaucophane and epidote-glaucophane schists in a serpentinite melange. The polymetamorphic evolution revealed that 'eclogite' might have undergone the pre-Renge amphibolite-facies metamorphism before its subduction, and then experienced eclogite-facies metamorphism and blueschist-facies overprinting during the Renge metamorphism. The petrologic and geochronologic features of the Renge blueschist indicate that the 'cold' subduction-type (Franciscan-type) metamorphism to reach eclogite-facies and subsequent quick exhumation took place in the northwestern Pacific margins in Carboniferous time.

On the other hand, Early Paleozoic subduction metamorphism is newly identified from the Fuko Pass metacumulate in the Oeyama ophiolite. The Fuko Pass metacumulate has been recrystallized

by the high-pressure epidote amphibolite facies metamorphism, and contains the assemblage kyanite + clinozoisite + paragonite + albite. This mineral assemblage is only realized at a deeper part of a subduction zone. In addition to the high-pressure metamorphism, granulite facies relics are rarely found. The Fuko Pass metacumulate is one of such rare allochthonous mafic granulites and may be an indicator of accretion of thick oceanic plateau, and the high-pressure metamorphism may imply the beginning of subduction in the paleo-Pacific margin at Early Paleozoic time.

The Renge metamorphic belt and the Oeyama ophiolite in southwestern Japan are Paleozoic subduction complex and supra-subduction zone ophiolite, respectively, which are the products of Paleozoic plate convergence in the circum-Pacific orogen. The regional studies of the Early to Late Paleozoic subduction-related high-pressure metamorphic rocks revealed that the two different subduction events in Late Paleozoic and Early Paleozoic had taken place in southwestern Japan.The Paleozoic ophiolite with subduction-related high-pressure metamorphic rocks in southwestern Japan is a good example for studying Paleozoic subduction tectonics through a joint geochronologic - petrologic method. The key results on the Paleozoic high-pressure (subduction-related) metamorphic rocks, as documented in this thesis, are summarized as follows:

(1) Two different high-pressure metamorphisms are documented from the Renge metamorphic belt and Fuko Pass, respectively. Typical HP/LT metamorphism to produce the lawsonite-glaucophane schists had taken place in the Renge belt during Late Paleozoic time (ca. 320 Ma). The oldest subduction metamorphism (ca. 430 Ma) is newly identified from the Fuko Pass metacumulate which may represent exotic block tectonically trapped into the peridotite body of the Oeyama ophiolite.

(2) The Renge metamorphic belt has been fragmented during exhumation and nappe emplacement, and the Renge HP/LT schists often occurs in a serpentinite beneath the peridotite body of the Oeyama ophiolite. Systematic determination of K-Ar phengite ages for the blueschist tectonic block within a serpentinite melange verified a primary coherency of blueschist facies metamorphic sequence. Phengite K-Ar ages yield 289-327 Ma and concentrate around 320 Ma regardless of protolith and metamorphic grade, suggesting quick exhumation of the schists at about 320 million years ago.

(3) The most deeply subducted example of the Renge metamorphic belt is an eclogitic garnet-glaucophane schist occurring as tectonic block of a serpentinite melange in central Chugoku Mountains. The eclogitic garnet-glaucophane schist preserves relics of peak eclogite facies assemblage (garnet + omphacite + glaucophane + rutile + quartz) and earlier stage amphibolite facies assemblage (hornblende + garnet + plagioclase + ilmenite), and overprinted the blueschist facies metamorphism prior to peak metamorphism. Thermobarometry of the garnet and omphacite of the peak eclogite stage yields minimum pressure of 1.3GPa at about 550 °C.

(4) The Na-Ca pyroxene + quartz assemblage occurs with lawsonite-glaucophane schists in Chugoku Mountains. The metabasalt containing the Na-Ca pyroxene + lawsonite + chlorite assemblage is intercalated among lawsonite-glaucophane schist. The chemographical analysis based on Schreinemakers' rule revealed that the stability field of Na-Ca pyroxene + lawsonite + chlorite assemblage is located within the lawsonite-glaucophane stability field, suggesting the typical HP/LT assemblage. It is inferred that the metamorphic facies series of the Late Paleozoic metamorphism passed higher pressure field than the Na-Ca pyroxene + pumpellyite + chlorite field which had been

found in the Sambagawa/Mikabu metamorphic belt.

(5) The protolith of the Renge metamorphic rocks are predominantly sedimentary rocks with subordinate basaltic volcanic rocks and tuff, and minor limestone. No graywacke is associated among the protoliths. However, some ophiolitic materials derived from the Oeyama ophiolite also experienced the blueschist facies metamorphism together with the Renge schists. Blueschist-facies metamorphosed/metasomatized ophiolite fragments and various metasomatized ophiolite fragments suggest that a part of the Oeyama ophiolite (representing supra-subduction zone wedge mantle) has been tectonically eroded by subducting oceanic lithosphere, and has experienced a HP/LT metamorphism and metasomatism in a deep part of the subduction zone with the Renge blueschist (subducted oceanic sediments).

(6) Early Paleozoic subduction is newly identified from the Fuko Pass metacumulate in the Oeyama ophiolite. The Fuko Pass metacumulate is recrystallized by the high-pressure epidote amphibolite facies metamorphism. The estimated P-T condition (P = 1.1-1.7 GPa, T = 550-650 °C) from the kyanite + clinozoisite + paragonite + albite assemblage and paragonite-muscovite immiscibility is only realized at a deeper part of a subduction zone. The breakdown of the kyanite + clinozoisite assemblage into margarite + plagioclase (An_{24-37}) assemblage indicates a decompression P-T path.

(7) The Fuko Pass metacumulate bears as much as 66 wt. % normative anorthite and 28 wt. % normative olivine. Its FeO*/MgO is as high as 2.4, and its protolith may be highly fractionated troctolite or anorthosite. The granulite facies relics including aluminous clinopyroxene (up to 8.5 wt.% Al_2O_3), spinel (replaced by corundum-magnetite symplectite) and plagioclase (replaced by clinozoisite-zoisite) are rarely preserved. The presence of granulite-facies relics predating the high-pressure metamorphism suggest that the Fuko Pass metacumulate has been a lower part of unusually thick oceanic crust (15-30 km) or lower crystalline portion beneath island arc setting before its subduction.

学位論文審査結果の要旨

本論文は，西南日本内帯に分布するいわゆる三郡変成岩類のうち，岡山県大佐山，鳥取県若桜，兵庫県大屋，新潟県青海などに露出する古生代後期(約320Ma)の三郡蓮華変成岩について，その高圧型変成作用を，地質学的，岩石学的，地球年代学的側面から克明かつ総合的に研究するとともに，京都府大江山に従来から知られていた藍晶石や十字石を含む変成岩を再調査して，これが更に古い時代(古生代前期，420Ma以前)の高圧型変成岩であることを明らかにし，従来断片的な研究しかなかった，古生代の環太平洋造山帯における海洋プレートの沈み込みテクトニクスの解明を大きく前進させた。特に，大佐山からのエクロジャイト相と角閃岩相の鉱物組合せを残す藍閃石片岩の発見，大江山の変成岩からのグラニュライト相残存鉱物の発見などは，特筆される成果である。

主な研究地域である大佐山の三郡蓮華変成岩類のカリウムーアルゴン年代が，原岩や変成度の違いにかかわらず一定の値を示すことと，それが沈み込み帯深部からの急速な上昇を示すことを論じた部分は，既に国際学術誌に印刷中であり，参考論文として添付されている。また，同地域の変成岩中のオンファス輝石と透輝石の間の不混和領域が非常に広いことを報告し，世界の変成岩中で最も低温での形成を示すことを論じた部分は，既に国際学術誌に印刷されて高い評価を得ており，同地域の変成岩類とオフィオライトの関係を地質学的に論じた日本語論文も日本地質学会研究奨励賞を受賞し，ともに副論文として添付されている。

以上のように，本論文は日本の古生代変成岩に関する研究を大きく前進させたものであり，十分に博士論文(理学)の学位に値すると判定される。